Excursion 2

Peatland Research on Mown and Grazed Rewetted Peatlands on the Darß Peninsula and in the Recknitz and Trebel River Valleys

Guides

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Excursion Programme

Time	Programme
08:00	Departure from Greifswald
09:30	First stop: Darß peninsula, coastal rewetted peatlands grazed by water buffalo
09:45	Change from bus to “Kremsers” (traditional horse drawn carts)
10:15	Buffalo grazing on drained and rewetted coastal peatland sites near the island of Schmidtbülten
11:45	Transfer to farm “Gut Darß”, information on farm activities (e.g., water buffalo grazing, peatland rewetting projects)
12:15	Lunch in farm restaurant
14:00	Transfer by bus to Recknitz valley
15:15	Second stop: Recknitz river valley, wet meadow management for biodiversity
16:00	Transfer by bus to Trebel valley
16:45	Third stop: Trebel river valley, research cluster (WETSCAPES2.0) investigation sites in rewetted peatlands in former LIFE peatland restoration project area
17:30	Return to Greifswald
18:15	End of excursion in Greifswald

Highlights

Grazing sites with water buffalos on Darß peninsula. Influence of buffalo grazing on coastal peatlands. First harbingers of migrating cranes. Management of near natural sites for conservation with site-adapted biodiversity promoting mowing in the lower Recknitz river valley. Study sites of major research projects on matter dynamics in rewetted peatlands of Greifswald and Rostock universities in the Trebel river valley (VIP, WETSCAPES, WETSCAPES2.0) in a peatland area that was rewetted > 20 years ago in a LIFE Europe project.

Landscape

The Recknitz valley is part of the river valley peatland system in Mecklenburg Vorpommern in North-East Germany. The connected valley system developed into a plateau of undulating ground moraines of the last glacial period (~10,000 years BP). In this plateau river valleys where ice-scored and mainly extend SW-NW in direction of the Glacier progression. The Recknitz valley today flows into the Saaler Lagoon near Ribnitz-Damgarten. The river Recknitz enters at Bad Sülze, the Pommeranian plain, and turns ~90 degrees to the North forming a bifurcated watershed with the River Trebel. In this watershed a bog developed on top of the extensive fen supported by the hydro climatic situation. It is called the "Grenztalmoor" or „Rauhes Moor" (literally translates as „rough mire"),. Together with the rivers Trebel and Tollense the lower Recknitz delineates the Western margin of the Pomeranian plain in NW-SE direction. All developed as meltwater valleys perpendicular to the retreating glacier front of the last glacial period. During the Littorina Transgression of the Baltic Sea ~7,000 BP these valleys were flooded with brackish water and water rise mires formed and accumulated large *Phragmites* radicell peat deposits. Later, extensive percolation mires formed sedge peat deposits on top of these up to three-kilometer wide valleys. The total peat depth in the Recknitz valley is up to >8 m.

The overall length of the river today is about 88.9 km with a small water level gradient of about 0.3 m between Bad Sülze and Ribnitz-Damgarten. Therefore, high water levels at the Saaler Bodden lagoon, that often occur during the winter months, may lead to backwater up to Bad Sülze, about 30 km inland. The first river regulations took place in the early 20th century to make the Recknitz navigable for small ships to allow for better transport. More—mainly straightening efforts and the cutting off of meanders—followed until the 1960s, reducing the length of the river course from 122 km to 69 km (https://de.wikipedia.org/wiki/Recknitz, last visited 2025-08-28). Hydrological regulations today comprise nine weir systems, two pumping stations, and dikes that allowed the intensification of grassland utilisation in the valley.

With ongoing drainage, problems of topsoil desiccation and degradation of the upper peat layers arose. Consequently, loss of water absorption capacity and of vertical capillary transport capacity of the peat resulted in lower productivity and a reduction of species numbers of flora and fauna.

Since 1990, a landscape protection area comprises about 5.450 ha of river, peatland and hillside area along its way. It includes three nature reserves and is registered as SPA and as FFH area. The main objective of the protection state is to maintain the large-scale unspoiled landscape integrating environmentally friendly, sustainable land use. About 200 ha of reed beds in the river valley and on the Darß-Pensinsula are harvested for thatching materials for roofs. Agricultural use comprises mainly grassland. Since 2000 parts of the river valley peatlands were rewetted and stream courses were restored to the original riverbed under different funding schemes.

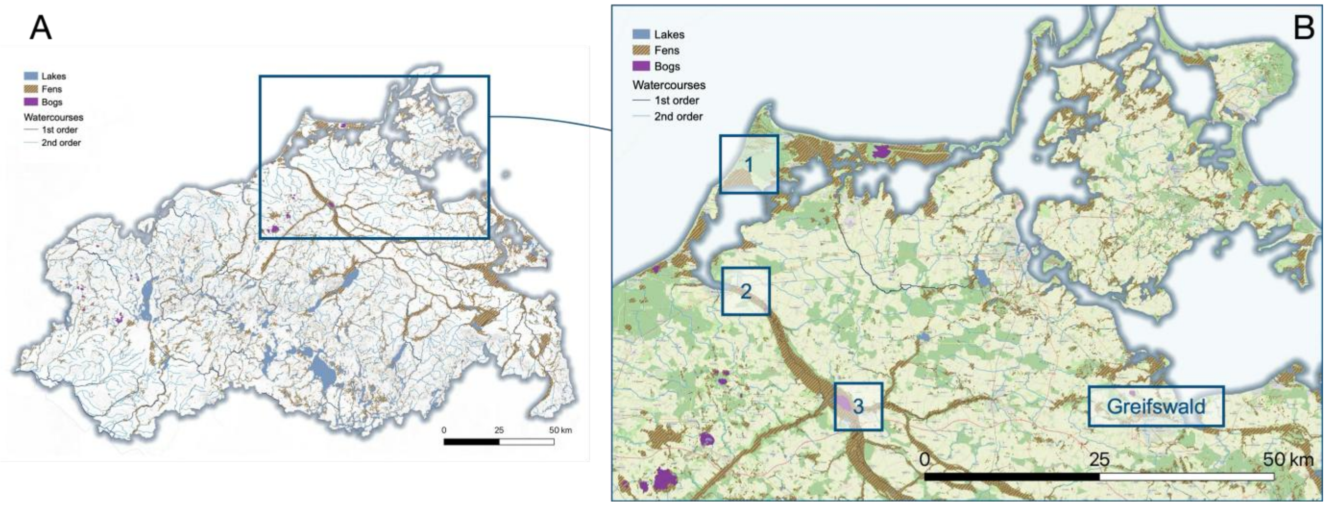

Fig 1: Where will we go with our excursion? **A:** Overview map of Mecklenburg-Vorpommern with its peatlands (Konzeptbodenkarte – Moorbodenformengesellschaften, last updated 23.11.2024, LUNG MV) and its waterbodies (based on the official WFS layers of the LUNG MV). The square shows the extent of the detailed map in **B:** Areas of the excursion sites (1= Gut Darss, 2 = Lower Recknitz valley near Freudenberg, 3 = Trebel River valley near Tribsees) and the location of Greifswald on an OpenStreetMap layer (https://www.openstreetmap.org used under CC-BY-SA) also showing the peatlands and watercourses (see A for sources).

Stop 1: Gut Darß: Drained and Wet Coastal Flooded Peatlands Grazed by Water Buffalo

General Information

Adjacent to the North and North-East of the Pomeranian plain the coastal area of the Baltic Sea is characterised by a graded shoreline with sand spits and lagoons (JURASINSKI & BUCZKO 2023). The Fischland-Darß-Zingst-Peninsula is a typical formation of counterbalancing coastal dynamics (*ibid*.). Abrasive sea currents that move along the coast take away material (sand and clay) on westerly exposed shorelines and deposit it easterly at current calm sites forming sand spits. In this way a set of lagoons was separated from the Baltic Sea on a length of ~50 km. The regional name of such a lagoon is “Bodden”. Due to the brackish and shallow water regime in the lagoons they are prone to eutrophication caused by nutrient inflow with the surface runoff from intensively used agricultural areas in the catchment of the tributary rivers. In consequence, the reed proliferates and nature conservation measures comprise mowing and grazing to manage reed encroachment. Traditionally reed is harvested in the area and used as roof thatch. The largest national park of Mecklenburg-Vorpommern is the National Park "Vorpommersche Boddenlandschaft” was established in 1990. With a total area of 805 km2 it is the third-largest national park in Germany.

Type of Peatland, Hydrological Condition, Land Use History

The excursion sites which we will visit, on the Darß peninsula, e.g. the “Schwinkelsmoor” and the island of “Schmidtbülten”, as well as the study area of the ‘Büffelwirtschaft’ project (Bliesenrader Moor) south of the village Born am Darß, formed as coastal flood mires that were sporadically flooded during high tides in the Bodden (lagoon) waters (Bodstedter Bodden). On many of these areas salt grassland developed due to management with grazing by humans over centuries (JESCHKE 1987). In the second half of the 20th centuries, in the course of the „complex meliorations“ undertaken in East Germany, many of these areas were diked and drained via ditches and pumping stations. It can be assumed that since the beginning of intensive drainage, the surface has lost 30 to 50 cm in elevation due to subsidence based on compaction and mineralisation (SUCCOW & JOOSTEN 2001). Today, there are only shallow peatlands without brackish water influence. Some of these areas can no longer be classified as peatlands due to the low depth of the remaining peat layer.

Coastal flooding mires with salt marsh peat are a specialty among peatland types. Peat formation takes place above the mean water line of the Baltic Sea or its lagoon waters. Brackish reedbeds are pushed back by grazing and are replaced by plant communities dominated by *Juncus gerardii* (Blackgrass or Saltmarsh rush). The treading of cattle leads to a high degree of compaction of the underground biomass and thus to a reduction in oxidative decomposition on the regularly flooded areas. These peatlands are thus characterised by anthropozoogenic peat formation (JESCHKE 1987). The gradual rise in water levels as a result of isostatic equalisations in the southern Baltic Sea coastal region has significantly promoted peat growth. The beginning of the formation of coastal flood mires dates from the 13th century with the start of regular grazing (JESCHKE 1995). These coastal flood mires thus represent relatively young mire formations with thin peat layers, with comparatively high mineral contents caused by sediment input during sporadic flooding.

Peat-preserving or even peat-forming management is generally no longer possible from water level class[1] 4+ or lower in, e.g., deep-lying fen peatlands like “Durchströmungsmoore” (percolation mires). Here, only the reduction of peat depletion is achievable without bringing up the water level. In coastal flooded peatlands, however, the boundary between wet reed and wet salt grassland stands lies at average groundwater levels between 13 cm and 24 cm below the surface, i.e. peat-preserving or peat-forming conditions are already present at water level 4+ (SEIBERLING 2003).

Internationally, such coastal flood mires, such as the Karrendorfer Wiesen near Greifswald, are referred to as non-tidal coastal flood mires (AHMAD et al 2020). The coastal mire is represented by a mosaic of micro-elevational changes consisting of marly till and sandy soils, and interspersed low-lying areas (BERNHARDT & KOCH 2003) consisting of fen gley soils with 13-28 cm of peat (JANSSEN et al. 2019).

Further Characteristics / Site Specific Features / Paludiculture

The coastal marshes of the southern Baltic region are typically influenced by brackish waters from periodical flooding of the Baltic Sea. Brackish reed beds constitute the natural climax vegetation in these coastal marshes, but grazing has transformed this natural vegetation into anthropozoogenic salt marshes in many places (JESCHKE 1987). Grazing keeps the habitat open and can create a mosaic of „tidal“ creeks, seasonal pools, brackish pioneer vegetation, brackish marsh stands and reed beds when it is extensive enough. The spatial variation with diverse habitats encountered in these ecosystems supports a more species rich plant and animal community than monotonous brackish reed beds.

Suppressing Reed by Grazing with Water Buffalo (taken from a study by SWEERS et al. (2013))

Regular grazing has for instance created a typical brackish marsh with quite some rare species e.g. on Schmidt-Bülten, a 28 ha large island in the West Pomeranian lagoon. Abandonment or reduced grazing pressure has caused the vegetation – with its high conservational value, to be lost to succession towards reed beds. Some years ago, management of the island focused on grazing by suckler cows with low livestock density (0.6 livestock units per hectare, LU ha^{-1}). However, this low livestock density proved to be insufficient in conserving the open brackish marsh parts. Instead, reed beds developed in the wetter areas (soil moisture class 5+) and regular grazing remained restricted to the drier parts of the island (soil moisture class 3+). Parts of the dry area were even overgrazed, resulting in decreased species richness. Since June 2010, water buffaloes have been used for grazing on the island in order to restore the typical brackish marsh vegetation and to suppress the encroaching

[1] Water level classes (Wasserstufen) are derived from the plant community composition and reflect the average water level at the site and its mode of variation. There have been several deductions of water level classes. We here refer to KOSKA 2001, published in SUCCOW & JOOSTEN 2001.

reed beds. A livestock density of 1.0–1.3 LU ha^{-1} and 123–148 grazing days per season seemed to be sufficient to reduce the area of reed beds by 30%. Like the suckler cows, the water buffaloes preferred the drier parts of

the island with its high-quality fodder at the beginning of the grazing season. Nonetheless, the animals did disturb the reed beds already early in the season by regular trampling and some grazing on young shoots.
As the amount of available fodder decreased during the course of the grazing season, the buffaloes more regularly fed on the young reed culms, allowing understory plants to benefit (mainly *Agrostis stolonifera* ssp. *maritima* and *Juncus gerardii*). After some time, the suppression of reed has led to an increase in the grazing area (which, in 2012, required a slight increase in the livestock density) in order to keep grazing pressure at a level required to break the dominance of highly competitive helophytes. In order to create favorable conditions for meadow bird conservation, livestock densities must not exceed 1.4 LU ha^{-1}.

Biodiversity/Rare Species /Current Restoration Projects, Research/Scientific studies

We are currently continuing to assess and improve the ecosystem services provided by water buffalo grazing on coastal wetlands. In order to maintain the landscape conservation-oriented grazing system even after the abolition of area payments, appropriate individual animal performance is required to ensure economic viability. When approximately two-thirds of the grown plant energy is converted into metabolic energy of buffalos, the regulating ecosystem services remain at a high level according to our studies. We consider the energy conversion rate of wetland plants into metabolic energy of the grazing animals to be a better criterion for estimating appropriate stocking rates at specific sites than a fixed stocking density expressed in LU ha-1 for all coastal grasslands. Recent studies on browsing intensity have shown that water buffaloes browse dominant stands of helophytes to a greater extent than cattle (e.g. SWEERS et al. 2013). This applies not only to reeds, but also to tall sedges and rushes, thereby promoting phytodiversity. We were able to identify more than 120 different beetle species on the coastal water buffalo pastures, including many rare and protected species. While there were few differences between cattle and buffalo pastures among coprophagous species, water buffalo pastures showed significantly higher abundances of hydrophilic Coleoptera species.

Potential for climate protection

For a representative study area on the Darss peninsula, various rewetting options were compared with each other in terms of their saving potential with regard to greenhouse gas emissions (GHG) (SELZENER & WICHTMANN 2025). A comparison of the GHG savings potential per year was made for various development scenarios for the study area on the Darss (40.03 ha). The savings are calculated from the difference between the status quo (drained state) and the rewetted state (see Tab. 1).

Fig. 2: Left Wallowing buffalos. **Right** Buffalos on a wet pasture on a coastal flood peatland on Usedom island, water level class 4+/5+ (Fotos: W. Wichtmann)

Tab. 1 Comparison of scenarios regarding their greenhouse gas emissions and savings in comparison to the status quo based on a study by SELZENER & WICHTMANN (2025).

Scenarios	GHG-Emissions per Year (t CO_2-Äq. Yr^{-1})	GHG-Savings (%)
Continued drainage	910,25	0,0
Some rewetting	606,79	33,3
Moderate rewetting	456,13	49,9
Rewetting most of the area	334,80	63,2

Stop 2: Recknitz River Valley: Harvested Wet Fen Peatlands for Biodiversity near Freudenberg in the Recknitz Valley Lowland Fen Peatlands

Site Description

The fen peatland is located near Ribnitz-Damgarten close to a small settlement called Freudenberg in the lower stretches of the river Recknitz. Locally it is called „Einhusen". The site has no formal protection as a nature reserve, but it is part of the landscape conservation area[2] „Recknitztal" and of a larger bird protection and Natura 2000 area. It is an example of a percolation fen with relatively good state of preservation and exhibits near-natural wet conditions. The water levels are mainly influenced by groundwater inflow/throughflow as it is typical for percolation (through-flow) fens. Closer to the river, the water level of the river Recknitz also has an impact and the characteristics change to that of a flooding fen with more nutrient and occasional sediment input. Due to the vicinity of the Bodden lagoons, there might be some brackish influence as well but the Saaler Bodden close to Ribnitz-Damgarten is already the farthest away from the sea along the lagoon chain so that the water has low salinities to begin with.

Type of Peatland, Hydrological Condition, Land Use History

The Recknitz valley is part of the river valley peatland system (see Fig. 1) that stretches through Mecklenburg-Vorpommern in the North-East of Germany. These valleys were carved into a plateau of undulating ground moraines of the last glacial period (~10,000 years BP) by huge meltwater rivers. The valley of the Recknitz extends SW-NW in direction of the glacier progression and flows into the Saaler Bodden lagoon near Ribnitz-Damgarten (https://de.wikipedia.org/wiki/Recknitz, last visited 2025-08-28). The river Recknitz enters the Pommeranian plain from SW and turns ~90 degrees to the North forming a bifurcated watershed with the river Trebel (that enters from East Northeast and turns into South Eastern direction. In this watershed, the Grenztalmoor is situated. Together with the rivers Trebel and Tollense the Recknitz delineates the Western margin of the Pomeranian plain in NW-SE direction as meltwater valleys perpendicular to the retreating glacier front of the last glacial period. During the Littorina Transgression of the Baltic Sea ~7,000 BP these valleys were flooded with brackish water and after a liming phase that is often present in peat cores with thick gyttja deposits at the bottom, paludification mires formed and accumulated large peat deposits built from common reed rootlets (*Phragmites* radicells). Later extensive percolation mires formed sedge peat deposits on top of these in the up to three kilometer wide valleys. Total peatland depth in the Recknitz valley is up to >8 m. The overall length today is about 88.9 km (counting in the first segments that are locally known as Schaalbeke and Korleputer Bach). In the lower catchment the water level gradient between Bad Sülze and Ribnitz-Damgarten

[2] Landscape conservation areas (Landschaftsschutzgebiete) are widespread in MV (and Germany) and represent a low protection category. Their main objective is the preservation of the general landscape.

(20km) is very low with a height difference of only 0.3m. High water levels at Saaler Bay Lagoon may lead to backwater up to Bad Sülze and beyond, about 30 km inland. The first river straightening regulations took place in the early 20th century to increase water runoff. More followed until the 1960s, which reduced the river course from 122 km to 69 km (without Korleputer Bach and Schaalbeke). Hydrological regulations comprise nine weir systems, two pumping stations, and dikes that were constructed along some stretches of the Recknitz to intensify grassland utilisation. With ongoing drainage, problems of topsoil desiccation and degradation arose with top peat layers drying out. This led to a loss of water, of absorption capacity, and of capillary transport capacity of water, resulting in lower productivity and reduction in the species numbers of flora and fauna.

Since 1990 a landscape conservation area (see above) comprises about 5.450 ha of river, peatlands and hillside along its way. It includes three nature conservation areas and is also registered as a European bird protection area as well as FFH (Natura 2000) area. The main protection goal is to maintain the large-scale spacious unspoiled landscape integrating environmentally sound sustainable land use. About 200 ha of reed beds in the river valley and on Darß Pensinsula are harvested for thatching roofs. Agricultural use comprises mainly grassland. Since the year 2000, parts of the river valley peatlands were rewetted and stream courses restored to their original riverbeds under different funding schemes.

Paludiculture / Site management

The area possesses high biodiversity value, which, due to the slightly disturbed hydrology, can only be preserved through regular conservation management. This management is funded by various sources, including money from the regional nature protection administration and some support from time-limited project resources (some funding for instance was received from the biodiversity Hotspot 29[3] projects). In midsummer, the site is harvested using adapted conventional machinery. The biomass is transported out of the site and deposited on mineral soil close to the fen. From there, the biomass is taken by a composting plant for compost production.

Hotspot 29 „Schatz an der Küste“ is a joint project for biodiversity protection from the BfN (German federal agency for nature protection) funded by the now expired programme “Hotspots of biological diversity in Germany”. The Hotspot 29 project region is one of 30 accredited Biodiversity Hotspots in Germany (ACKERMANN & SACHTLEBEN 2012) and covers 1,211.79 km^2 in the Vorpommern lagoon landscape between the Rostocker Heide and the western part of the island of Rügen. The nine project partners in the Hotspot 29 project dealt with diverse issues of biodiversity protection in the project area addressed by ecosystem restoration in the coastal floodplain, development of sustainable land use schemes, environmental education, and participatory measures. The Succow Foundation (partner in the Greifswald Mire Centre) processed a work package dealing with the development of adapted technology and management of wet (rewetted) peatlands. In this work package the “Einhusen” model site was selected for repeated sustainable utilisation of aboveground biomass (reeds).

First harvest activities via the project were realised in 2015 by the landscape maintenance company Meyer Luhdorf with special equipment based on a modified snowcat in order to reduce management costs and to develop an approach that is feasible and attractive for agricultural farms (A. Haberl, perc. comm.). From 2016 to 2020 the Succow Foundation cooperated with the agricultural enterprise LWB H. Voigt from Neukalen to develop adapted accessory equipment compatible to already adapted trucks of the farm enterprise (light weight plus large contact area by huge low pressure wheels). It was decided to concentrate on the approach of

[3] Biodiversity hotspots in Germany are funded from the federal agency for nature protection and are widely scattered across Germany. More info (in German) can be found here: https://www.bfn.de/bpbv-hotspots

agricultural enterprise LWB H. Voigt for harvesting grass biomass for energy production in late summer from wet and rewetted peatland sites for use in the Agrotherm heating facility in Malchin.

Fig. 3: Management of the „Einhusen" site in the lower Recknitz valley. **Left:** Harvested biomass at the edge of the peatland, waiting for transport. **Right:** Sward effected by snowcat harvester (Fotos: A. Haberl).

Additionally, the baling unit and the logistics for the clearing of the harvested sites from the baled biomass were improved. A light weighted baler was modified by enlargement of the contact area and to lower ground pressure. For minimising site crossings during the clearing of bales, a management practice from dry and mineral soils with a loading-trailer equipped with a deck crane was transferred to be used on wet and organic soils. The trailer was dimensioned for loading 25 bales and equipped with a tandem axis and large low pressure wheels.

Stop 3: Trebel River Valley near Tribsees

Wetscapes Project Investigation Sites in the Trebel River Valley Fen Peatlands (Gas Exchange Measurements, Productivity of Vegetation, etc..)

Site Description (adapted from JURASINSKI et al. 2021 and HUTH et al. 2013)

The visited site in the Trebeltal is located northwest of the town of Tribsees in the municipality of the same name in the district of Vorpommern-Rügen and is part of an over 3000 ha, EU-LIFE-financed project area with the aim of "moor revitalisation" (Fig. 1). The area is characterised by a percolation fen as it is typical for the large river valleys of the southern Baltic region (see also above the descriptions at excursion point 2). It has its origin in spring fens of the early Holocene (Pre-Boreal and Boreal, MICHAELIS 2000; from GREMER & MICHAELIS 2003). The Trebeltal has a width of about 1 km at the level of the excursion site. A little bit further North, the valley has a width of over 3 km. Here, an n-valley water divide exists today, the so called Grenztalmoor[4]. Extensive fens grew here in the river valleys of the Recknitz and Trebel starting with the Littorina transgression approx. 8,000 years ago (REINHARD 1963; from BÖNSEL & RUNZE 2005).

Type of Peatland, Hydrological Condition, Land Use History (ibid.)

The Trebeltal is located in a year-round humid climate with continental character. The average annual temperature is 9.1°C (1991–2010, DWD), the average temperature of the coldest month of January is -1.5 °C

[4] ***Grenztalmoor*** translates to „border valley mire". It is called like this because the NW to SE stretching Recknitz/Trebel valley marks the border between Mecklenburg and Vorpommern for a long time.

and the warmest month of July is 19.6 °C. The annual rainfall is 626 mm (1981–2010, DWD). The climatic water balance is positive with +50 – +100 mm (KLÄMT & SCHWANITZ 2002). According to the investigations within the framework of the joint project WETSCAPES (see below for more details), the effects of the European summer drought in 2018/2019 were also recognised here and led to temperatures (+1.33°C in 2018, +1.54°C in 2019) significantly above the climatic average of 1981-2010 and – especially in 2018 – to precipitation significantly below the average of this period (-116 mm in 2018, JURASINSKI et al. 2020).

The peat body at the excursion site has a medium depth of 4 to 6 m and consists largely of reed and sedge peat, which developed on top of gyttjas of varying depths (between 0.2 - 1.4 m). The initial substrate consists of fine to clayey sands for the most part (INSTITUT FÜR GRÜNLAND UND MOORFORSCHUNG PAULINENAUE 1965, 1967). In the watershed area between the Recknitz and Trebel valleys, in the already mentioned *Grenztalmoor*, located a bit Northwest of our excursion point, a bog developed. Bog growth started comparably late approximately 2,000 years ago and at the begin of the first drainage measures in the 18th century the bog covered over 400 hectares. In the 19th century, a cotton grass peat moss peat of 1 m thickness was recorded (PRECKER 1995; from GREMER & MICHAELIS 2003).

Until the end of the 17th century, the area of the *Grenztalmoor* was not drained, but was already mapped as "forest and pasture" (SWEDISH MATRIKELKARTE 1697, CURSCHMANN 1944; from GREMER & MICHAELIS 2003). In 1744, a peat cut („old town pit“) was excavated in the bog complex and afterwards, approx. 1800 a large shippable channel, the Prahmkanal[5], was created to large amounts of extracted peat that was used for the combustion of the salt producing plant (Saline) of Bad Sülze (the name also points to the salt production), which was in operation until 1907. Large-scale drainage existed, especially on the Vorpommern side from 19th century onwards according to the analysis of old maps (GREMER & EDOM 1994; from GREMER & MICHAELIS 2003), however, the valley fen areas were only occasionally used for litter extraction. In the 19th century, there was already a widely branched ditch system, which allowed the use of meadows and pastures in the summer. Starting in the 1960s, intensive drainage measures were carried out (so-called „Komplexmelioration“) including the construction of the Trebel canal, the deepening, expansion, and re-organisation of the ditch system, as well as the construction of a new pumping station. As a result, the fen was intensively cultivated, including sowing in of favoured grass species, fertilisation and several harvests per year.

Since re-wetting measures were taken, starting in 1997, these areas have only been used for hunting and for some research. Any other use was discontinued with the implementation of re-wetting. Before re-wetting, intensive grassland farming with corresponding species-poor vegetation took place on large areas of the fen. In the western part of the area, some grass cutting takes place, if the water levels allow it.

With the removal of the pumping stations and the dismantling of drainage ditches in the summer of 1997, a hydrological protection zone was established around the former bog complex. This made it possible to raise water levels from before on average 50 cm under the surface by 30 to 40 cm. Due to unstable water supply in large parts of the peatland, re-wetting measures were enforced and damming was significantly extended in 2001, resulting in a further increase in water levels by 10 cm (BÖNSEL & RUNZE 2005). Since then, the target water levels have been reached in most areas and have been classified as stable (*ibid*.), although in the last years, occasional observation told a different story. According to the above cited study, the water level class 5+ has been reached on 50% of the area, which corresponds to the state of a growing bog. The water level class 4+/5+, which at least corresponds to the state "bog conservation" (KOSKA 2001 in SUCCOW & JOOSTEN 2001), has been reached in 90% of the area. In addition, a back-swelling of the peat was detected in large parts of the peatland by up to 10 cm (BÖNSEL & RuNZE 2005). Problems with water retention still exist in the northern and

[5] There are quite some large ditches of rather canals with the name „***Prahmkanal***“ in Mecklenburg-Vorpommern. The name points to the fact, that these channels were built for large lengthy boats with shallow draft that were called Prahm and that were mostly hauled by people or animals to transport peat or wood.

western parts of the peatland; the southern areas of the fen, which are located towards the Trebel, have the most stable water levels outside the nature reserve „Grenztalmoor“ that is located in the core area of the LIFE project (WACHLIN et al. 2003).

Here, we established research sites many years ago in the framework of large collaborative research projects where greenhouse gas exchange and other peatland science topics have been addressed during the joint projects "VIP - Vorpommern Initiative Paludiculture“ (2010 – 2013) and "WETSCAPES - material conversion processes at bog and coastal locations as a basis for land use, climate impact and water protection“ (2017 – 2021). Within the framework of WETSCAPES, new peat formation and a peat growth of more than 10 cm since re-wetting was detected by means of an interdisciplinary examination of a short (50cm) peat core taken in the excursion site 3 (see Fig. 1) (MROTZEK et al. 2020).

The VIP Project

The aim of rewetting of drained peatlands is to bring down the typically high carbon dioxide (CO_2) and potentially high nitrous oxide (N_2O) emissions and, thus, bring down their overall climate impact. Under paludiculture, the use of the above-ground biomass takes place on wet peatland sites. However, the vegetation in peatlands is often linked in many ways to the emission behaviour of these sites. Before the WETSCAPES project there was almost no data available on greenhouse gas emissions of rewetted peatland used for paludiculture. We, therefore, studied the influence of an extensive cutting on the balances of greenhouse gases CO_2, CH_4 (methane), and N_2O. For this purpose, 18 measuring spots were installed in the site of excursion point three with each 6 of them being installed in a *Phragmites*, *Typha* and *Carex* dominant stands (GÜNTHER et al. 2015). At half of the measuring points (3 per stand), a cutting use was simulated once a year (*Phragmites* and *Typha* stands were cut in Winter, the *Carex* stand was cut in summer). The greenhouse gas emissions at the installed measurement spots were examined over two years based on bi-weekly GHG exchange measurements with closed chambers (GÜNTHER et al. 2015).

15 years after re-wetting, the emissions of the study area were in the order of magnitude of those of natural fens (ibid.). No high CO_2 emissions were detected, as they would occur in drained fens. Severely increased CH_4 emissions, as detected by some studies directly after rewetting with permanent water-logged conditions afterwards, also did not occur. N_2O emissions were lower than the measured accuracy achieved over the entire study period and were therefore not different from zero. The summarised climate impact of all locations fluctuated around climate neutrality in both years. The average use had no significant effect on the level of CO_2 or CH_4 emissions. However, it is possible that a long-term, repeated biomass withdrawal shifts the production/oxidation balances of the two gases and can thus maybe permanently change the balances.

The WETSCAPES Project

In the large collaborative research project WETSCAPES we worked on a better understanding of turnover and exchange of matter in wetlands to foster better land management, climate adaptation and protection of water bodies. The objective was to develop scientific foundations for a sustainable management of degraded and then rewetted peatlands. We quantified the production and decomposition of above- and belowground biomass in temperate peatlands, with a special focus on root processes. These are key factors in the overall assessment of the carbon budget, because primary production of plants determines the amount of carbon input into these peatlands. Particularly important for the formation or vanishing of peat is the growth and turnover of root biomass. Since these factors were (and still are) understudied in the peatland types in question we included investigations into this matter in WETSCAPES. The project was funded by the Programme for Excellence in Research Mecklenburg-Vorpommern for a duration of 4 years (2017 to 2020).

Within the WETSCAPES project, the land use change of the last 200 years was characterised and quantified by comparing historical maps (Preußisches Urmesstischblatt 1835, Messtischblatt 1885) with current information (Mecklenburg-Vorpommern Peatland Protection Plan, current land use and peatland extent based on data of the Global Peatland Database (TEGETMEYER et al. 2020), digital site map of the Landesforst MV). The landscape was profoundly altered in the last 200 years (Fig. 4).

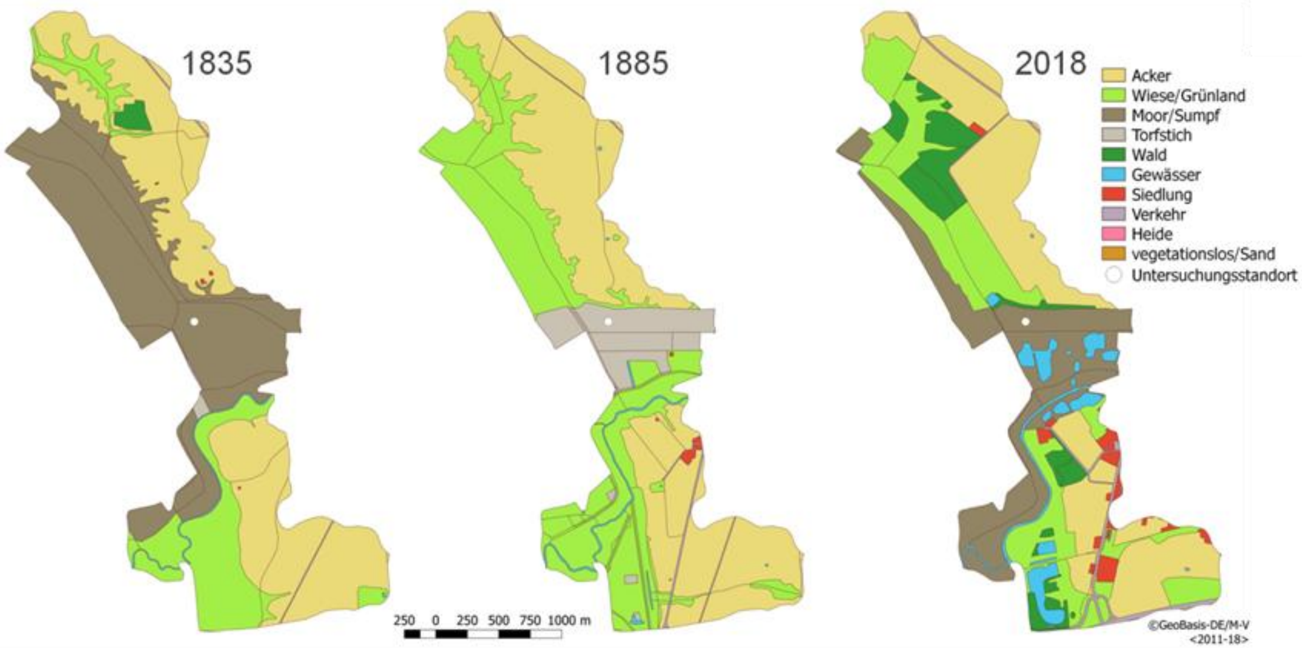

Fig. 4: Land use at the re-wetted percolation fen around the Tribsees site on the basis of, **Left:** the Prussian Urmesstischblatt (1835); **Middle:** the Messtischblatt (1885), **Right:** the Digital Landscape Model or the Digital Topographic Map (2011-18).

In addition to the change in land use, the change in ecosystem service provision was also quantified in space and time. By including the information on the distribution of peatlands and other input data, it was possible to compare the ecosystem services actually available on the basis of the given land use with those potential ecosystem services that the included areas could have generated under natural conditions, regardless of the actual land use. The potentials and their specific contribution to peat formation and conservation were determined on the basis of the corresponding water level class or the quantified peat accumulation rate. The potential contributions to peat conservation were derived from the MV Peatland Protection Plan 2009 based on water level class analysis, while potential contributions to peat formation were derived from information on accumulation produced in the project. With the resulting ecosystem service potential and loss maps, the current ecosystem services are not only visually comparable to those from the past; it is also possible to generate detailed, overlap-free balances of, for instance, greenhouse gas exchange for each individual time cut (Fig. 5) or to create ecosystem service prize cards to evaluate rewetting measures.

WETSCAPES worked on a variety of peatland sites in Mecklenburg-Vorpommern (JURASINSKI et al. 2020) on a wide range of issues like i) analysing biomass productivity of above and underground biomass and decay rates linked with rewetting and site management; ii) integration of the microbiome with biotic and abiotic contexts, i.e. concerning methane emissions, seasonal dynamics, microbial activities; iii) using paleoecological research methods to characterise macro- and microscopic biomass degradation products to reveal how much peat has vanished since drainage and how much accumulated since rewetting; iv) quantification of water regime components, incl. capacity terms under different water management scenarios and vegetation types as well as water and nutrient fluxes with adjacent systems; v) analysing C, N, P, S cycles connected with rewetting and management to derive strategies for sustainable use and development of fen sites (i.e. sink function) based on understanding of substance conversion; vi) defining transport characteristics of peat with different degradation rates; and much more. Here we want to focus on two out of the wide range of topics: GHG exchange and peat regrowth after rewetting.

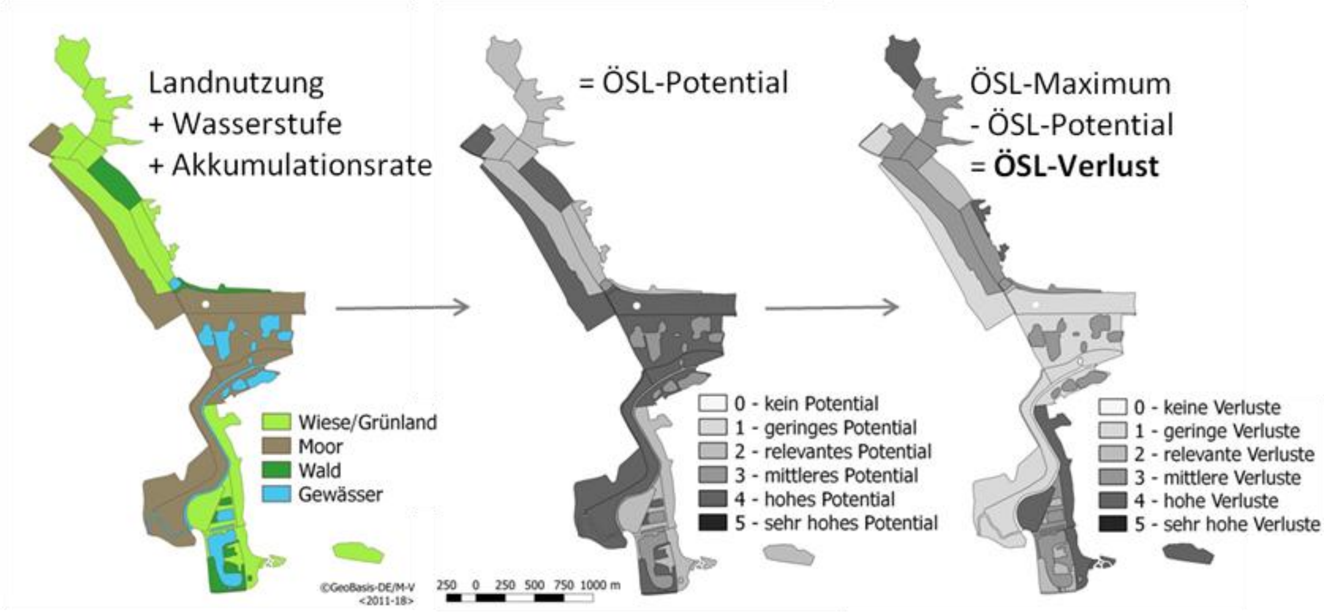

Fig. 5: From the land use map to maps of ecosystem service potential and loss: Global climate regulation of the potential peatland area on the re-wetted percolation fen around Tribsees (based on DLM and DTK 2011-18 and allocation of the specific water level classes and peat accumulation rates); ecosystem service maximum under the assumption that the potential peatland area would be 100% covered with peatland).

GHG exchange was addressed in two sub-projects, one addressing the carbon gases carbon dioxide (CO_2) and methane (CH_4) and the other one addressing nitrous oxide (N_2O). All measurements were carried out in the sampling plots for the whole project that were installed at the beginning of the project in 6 different sites in three pairs of two (each pair featuring a drained and a rewetted site): coastal fen, percolation fen, Alder carr. One of these sites, the rewetted percolation fen is part of the excursion site 3.

The exchange rates of CO_2 and CH_4 differed significantly in their heights as well as their seasonal and inter-annual fluctuations, between the variants drained and rewetted (Fig. 6, adapted from Abschlussbericht WETSCAPES 2021). The evaluation of the measurements of the greenhouse gas exchange of ditches in the re-wetted (excursion site 3) and drained percolation fen (about 7km northwest of the excursion site near Bad Sülze) have shown that the ditches contribute significantly to the total CH_4 exchange of the areas despite the small area share (KÖHN et al. 2021). Because of the otherwise very low CH_4 emissions in the drained percolation fen, the ditches there were the only big source of CH_4. However, due to the very low CH_4 emissions from the drained peatland, an almost zero CH_4 balance resulted overall. It can be assumed that this could turn into a CH_4 source simply because of a possible rise of the CH_4 emissions from the ditches at low intensity of ditch maintenance. In the excursion site, the rewetted percolation fen, the CH_4 emissions from ditches contributed between 50 and 90% to the CH_4 emissions of the total area, which is above values previously known from the literature (KÖHN et al. 2021). However, ebullitions only had a share of up to 10% of the total emissions (*ibid*.). Ultimately, the results showed that ditch emissions at the landscape level in drained and rewetted peatlands need more attention and should be included in overall budgets.

The N_2O fluxes showed large seasonal fluctuations and a high spatial variability between the measurement points per site. Both emissions and uptake close to zero fluxes were measured on all sites, but the cumulative fluxes from August 2017 to March 2020 indicate emissions of N_2O at the percolation fen sites. A clear influence of rewetting on the overall low N_2O fluxes was not detectable.

The average annual greenhouse gas exchange budgets show that the rewetted variants at the percolation fen sites perform significantly better in terms of GHG emissions than their drained counterparts (Tab. 2).

Tab. 2: Greenhouse gas exchange balances for the three measured gases CO_2, CH_4 and N_2O as average annual exchange based on the measurement data from October 2017 to September 2019. The shorter period of time compared to the C exchange rates results from the length of the shortest measurement series (N_2O). All values are given in g m^{-2} y^{-1}.

Site	Compartment	CO_2	CH_4	N_2O	Biomasse CO_2-eq
percolation drained	Peatland area	1509 ± 579	-0.1 ± 0.1	0.2 ± 0.4	164 ± 162
	Ditches	-	258.9 ± 314.8	-	
percolation rewetted	Peatland area	279 ± 360	18.6 ± 19.1	0.1 ± 0.3	-
	Ditches	-	613.1 ± 531.7	-	-

In Table 2, the GHG exchange balances for CH_4 and N_2O have not been converted into CO_2 equivalents, as it is often the case. Already in the first IPCC report, for which this simplified method of conversion was developed and used for the first time, the authors stated that this approach does not display the complete information and would only be used temporarily, because there was no better option so far (MYHRE et al. 2013). Like with many temporal solutions, the global warming potential (CO_2 equivalents) are still used widely. However, especially when addressing peatland greenhouse gas emissions, or better their climate impact, this approach hides important characteristics. It all boils down to the fact that CH_4 is comparatively short-lived and is broken down in the atmosphere after 12 years on average (to CO_2) while CO_2 accumulates. This has significant implications for the perception and problematisation of comparatively high CH_4 emissions after the rewetting of peatlands, which can much better be depicted based on radiative forcing modelling (GUENTHER et al. 2020).

We used the emission factors determined in WETSCAPES to estimate the longer-term climate effect of the GHG exchange with the same radiative forcing approach that was implemented in GUENTHER et al. 2020 (Fig. 15). It turns out that the rewetted percolation fen has a much less warming impact than the drained percolation fen (Fig 7). After a relatively short phase of increasing climate impact due to the CH_4 emissions at the beginning, the subsequent CH_4 emissions are almost in balance with the amount of methane that is degraded in the atmosphere per year, which is why the climate effect hardly changes, while the drained variant has an ever higher climate effect over time due to the addition of CO_2 to the atmosphere. The same approach was also used to compare how the explicit consideration of the emissions of the ditches affects this accounting (Fig. 7). We must take into account, however, that we only act here on the basis of two fully balanced years. When considering a longer time series, the possibility of significantly different courses is to be expected due to the considerable inter-annual variability of the GHG exchange.

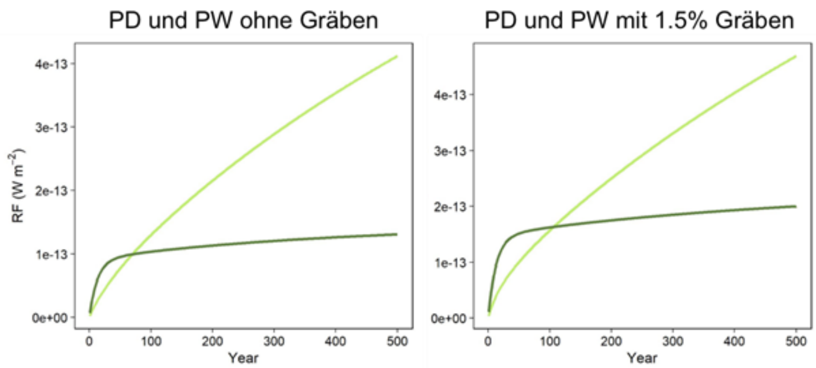

Fig. 7: Comparison of the climate warming effect of the drained and rewetted sites in the percolation fen (PD, PW) over time with (left) and without (right) including the ditch emissions. Adapted from Abschlussbericht WETSCAPES 2021.

The WETSCAPES2.0 Project

Since April 2025 we are working in an even bigger collaborative research cluster called WETSCAPES2.0. Organised as a SFB Transregio as a collaboration of the Universities of Greifswald and Rostock together with partners like IGB Berlin, GFZ Potsdam, MPI Biogeochemistry in Jena and the Ludwig-Maximilians-University Munich, the cluster is funded by the DFG (German Science Foundation). In WETSCAPES2.0 we are investigating the functioning of rewetted fens since these form novel ecosystems (KREYLING et al. 2021).

The CRC/Transregio WETSCAPES2.0 provides a functional understanding of these novel wetscapes, and addresses the spatio-temporal implications of peatland rewetting at landscape level and beyond. It integrates a consistent set of approaches, including (1) a chronosequence of rewetted Screening Sites in NE Germany, (2) Core Sites for detailed field observations in space and time, (3) Landscape Level controlled experiments (L-LExp), (4) Mesocosm Experiments (MCEcp) for causal understanding of relevant ecological functioning, and (5) process-based modelling to improve understanding and allow upscaling of findings. With its dedicated synthesis framework, WETSCAPES2.0 will thus quantify the environmental, climatic, and land use consequences of rewetting peatlands - a prerequisite for developing sustainable management. Some areas of the excursion site are part of one of the Core Sites in WETSCAPES2.0 and we are momentarily in the process of setting the site up for research in WETSCAPES2.0.

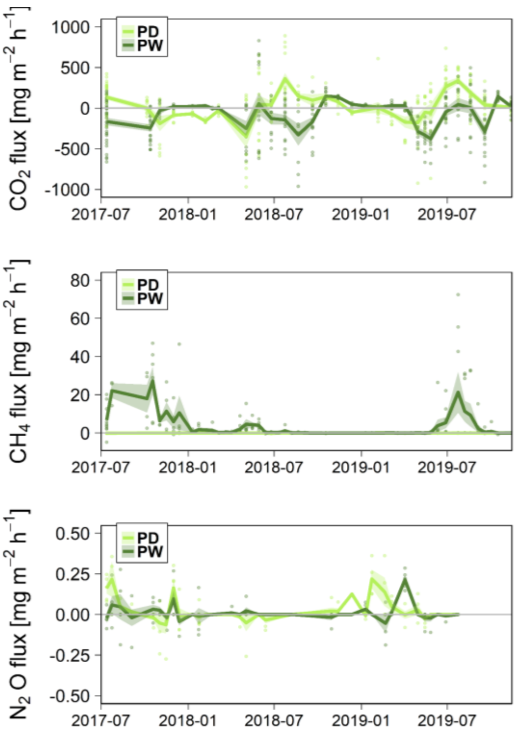

Fig. 6: GHG exchange over the covered measurement periods in the rewetted (excursion site 3) and drained percolation fen sites. Top: CO_2 (NEE), Centre: CH_4, Bottom: N_2O. All data in mg m^{-2} h^{-1}.

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